



Homeostasis in Reptiles and Amphibians

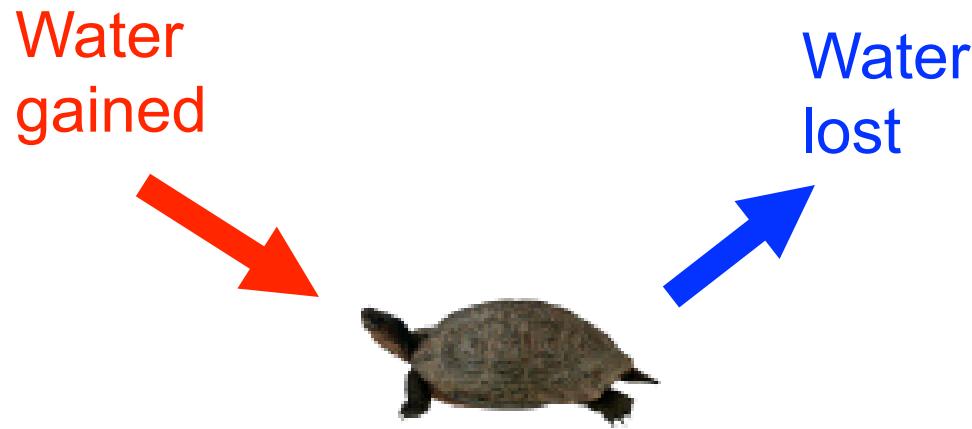
Homeostasis

- Water balance
- Heat balance
- Water and heat in the environment

Homeostasis

- Water balance
- Heat balance
- Water and heat in the environment

Water balance



At water balance:

Water gained = Water lost

Why does this matter?

- Organisms are mostly water (70-80%)
- Chemical reactions take place in water
- Circulation through blood
- Salt balance equally important
- Water interacts with temperature

Taking in water

liquid
water

preformed
water

metabolic
water

Taking in water

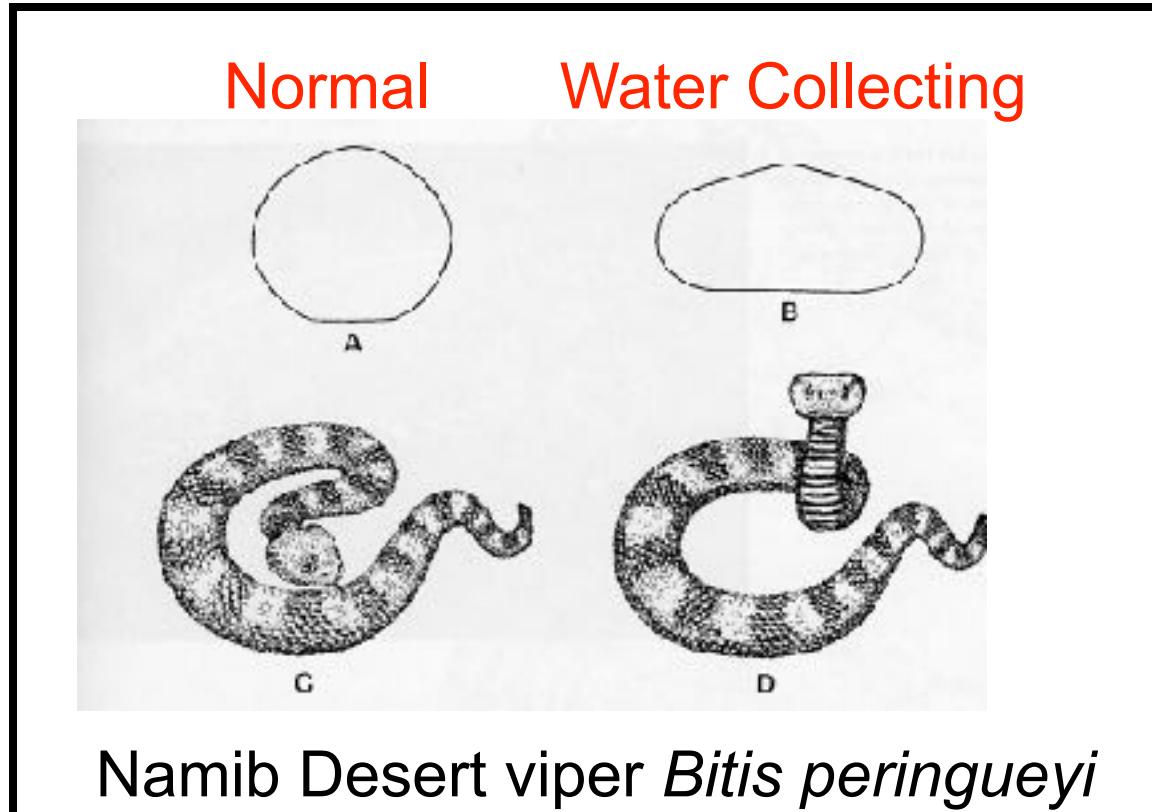
liquid
water

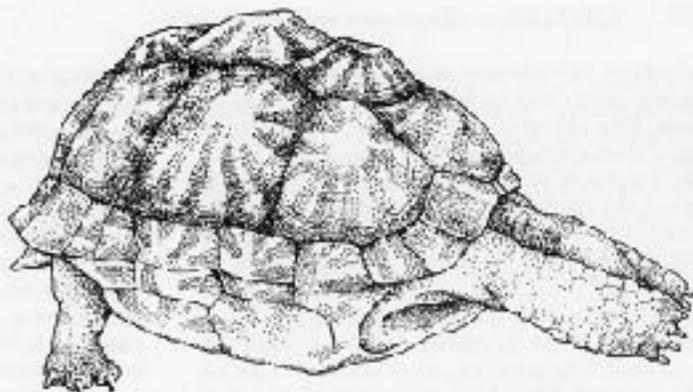
preformed
water

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water

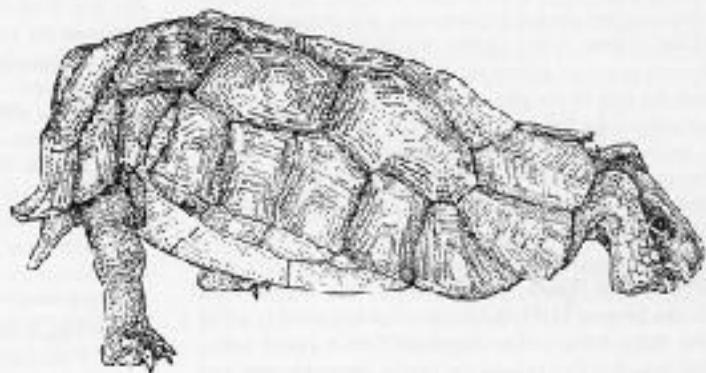
Liquid Water

- Reptiles drink from pools, puddles, etc.
- Can also collect liquid water in clever ways

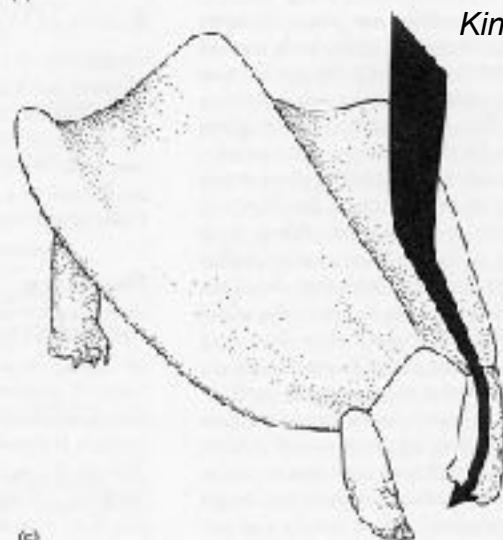




(a) *Psammobates tentorius*



(b) *Kinixys homeana*



(c)

Pough 2004



FIG. 1. Adult female *Phrynosoma cornutum* in stereotyped "rain-harvesting" stance, with jaws slightly opened for drinking.

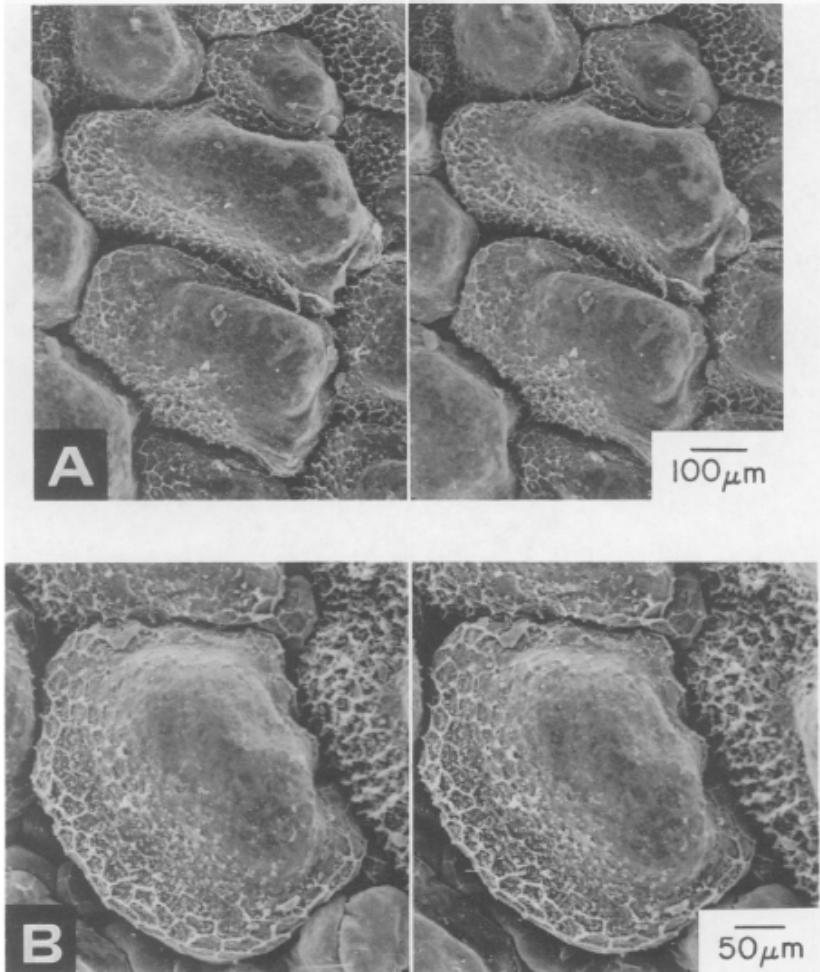
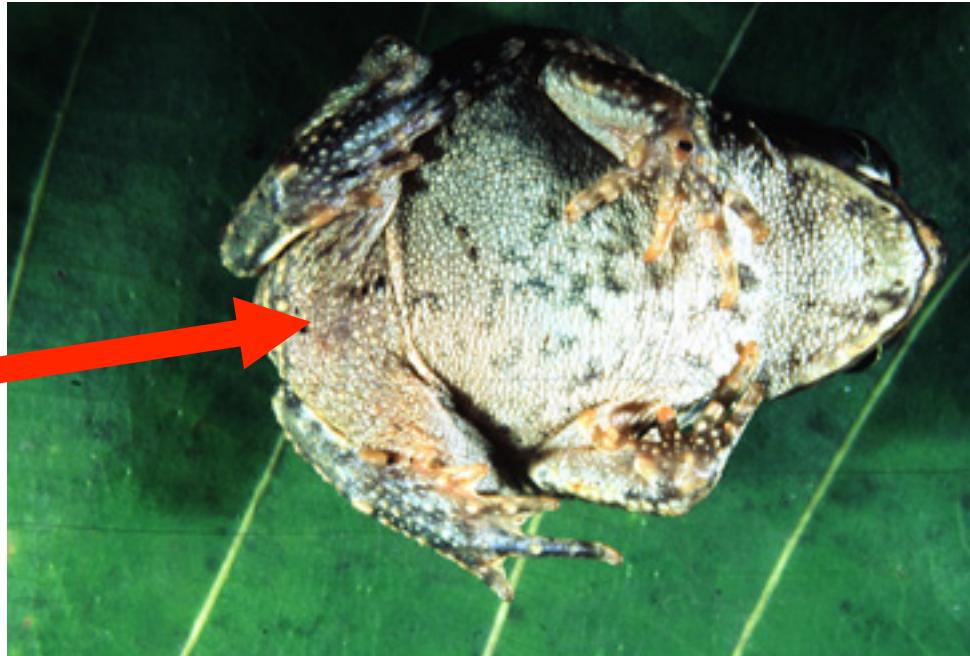


FIG. 2. Stereopaired SEM photographs of dorsal skin of an adult female *Phrynosoma cornutum*: (A) granular scales (between dorsal spines), showing interscalar channels and honeycombed micro-ornamentation around edges of scales; (B) detail of honeycombed micro-ornamentation extending down the walls of the interscalar channels, and small scales within the channels.

Liquid Water

- Amphibians do not drink
- They absorb water through their skin

Pelvic
patch

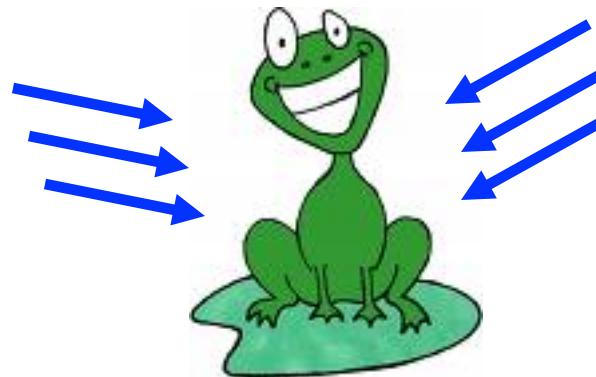


Osmosis

- Water moves from low to high salt concentration by osmosis



Spotted frog
Rana luteiventris



Osmosis

- Water moves from high to low salt concentration by osmosis



Spotted frog
Rana luteiventris



Osmosis

- Water moves from high to low salt concentration by osmosis



Spotted frog
Rana luteiventris



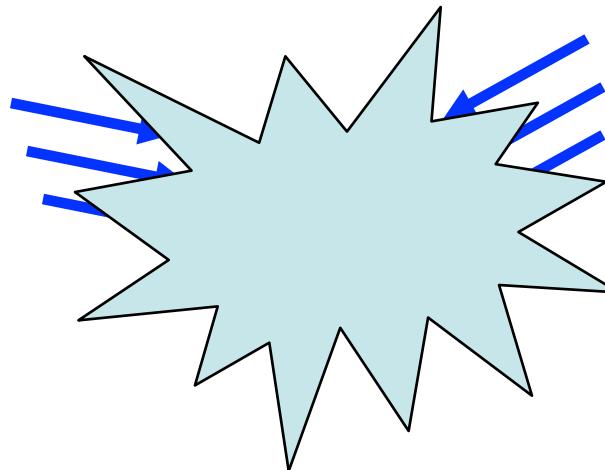
Osmosis

- Water moves from high to low salt concentration by osmosis



Washington Dept. of Fish and Wildlife

Spotted frog
Rana luteiventris

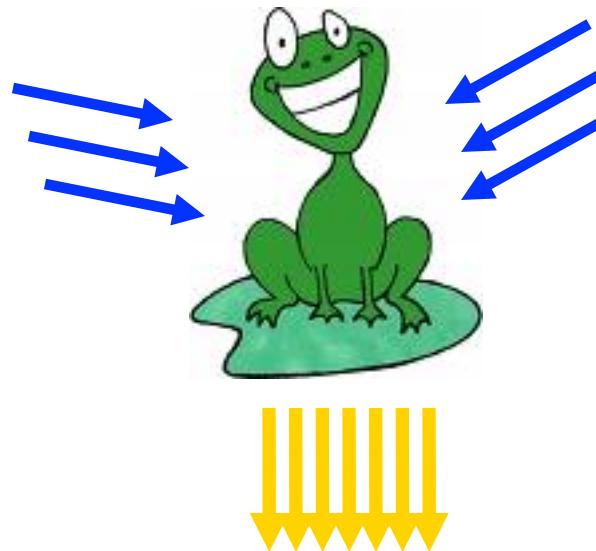


Osmosis

- Water moves from high to low salt concentration by osmosis



Spotted frog
Rana luteiventris



Osmosis

- Aquatic amphibians in freshwater produce large amounts of dilute urine
- Actively take up ions through skin to make up for losses in urine

Osmosis

- Water moves from low to high salt concentration by osmosis



Crab-eating frog
Rana cranivora

Osmosis

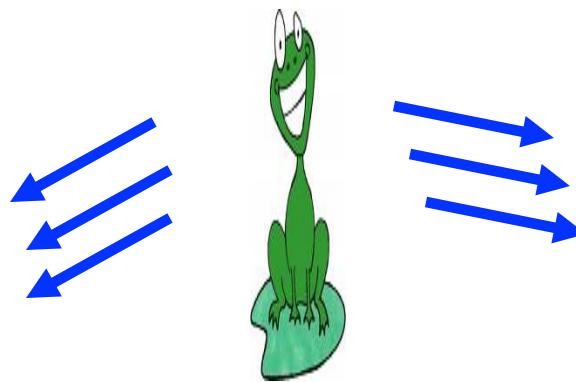
- Water moves from high to low salt concentration by osmosis



Crab-eating frog
Rana cranivora

Osmosis

- Water moves from high to low salt concentration by osmosis



Crab-eating frog
Rana cranivora

Saltwater frogs

- A few species of frogs can tolerate brackish water
- Example - crab-eating frog
- Salty body tissues
- Accumulates urea in blood at high concentrations

Taking in water

liquid
water

preformed
water

metabolic
water

Preformed water

- Water obtained from food
- Animals are usually 70-80% water
- Plants are more variable - can have positive or negative impact on water balance

Taking in water

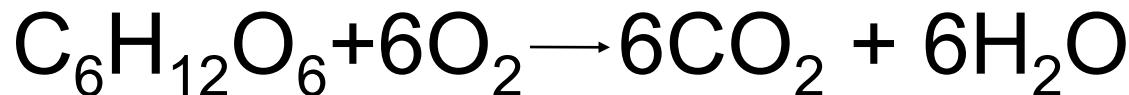
liquid
water

preformed
water

metabolic
water

Metabolic Water

- Water produced as a byproduct of chemical reactions
- Example: Aerobic respiration



- Can be substantial
 - 1g starch → 0.556 g water
 - 1g fat → 1.071 g water

Losing water

evaporation

urine and
feces

salt
glands

Losing water

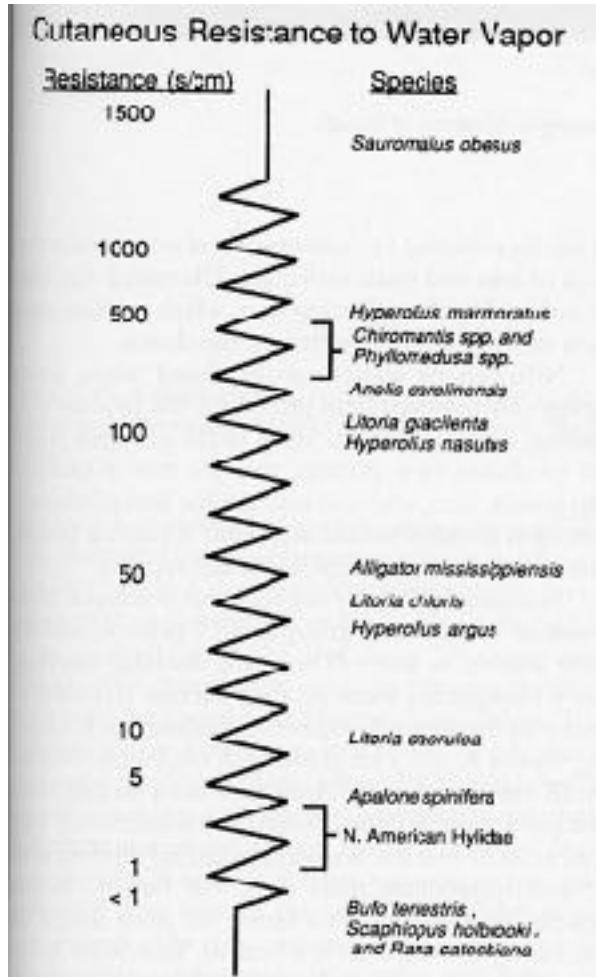
evaporation

urine and
feces

salt
glands

Evaporation

- Major route of water loss for terrestrial amphibians
- Not a major factor for reptiles



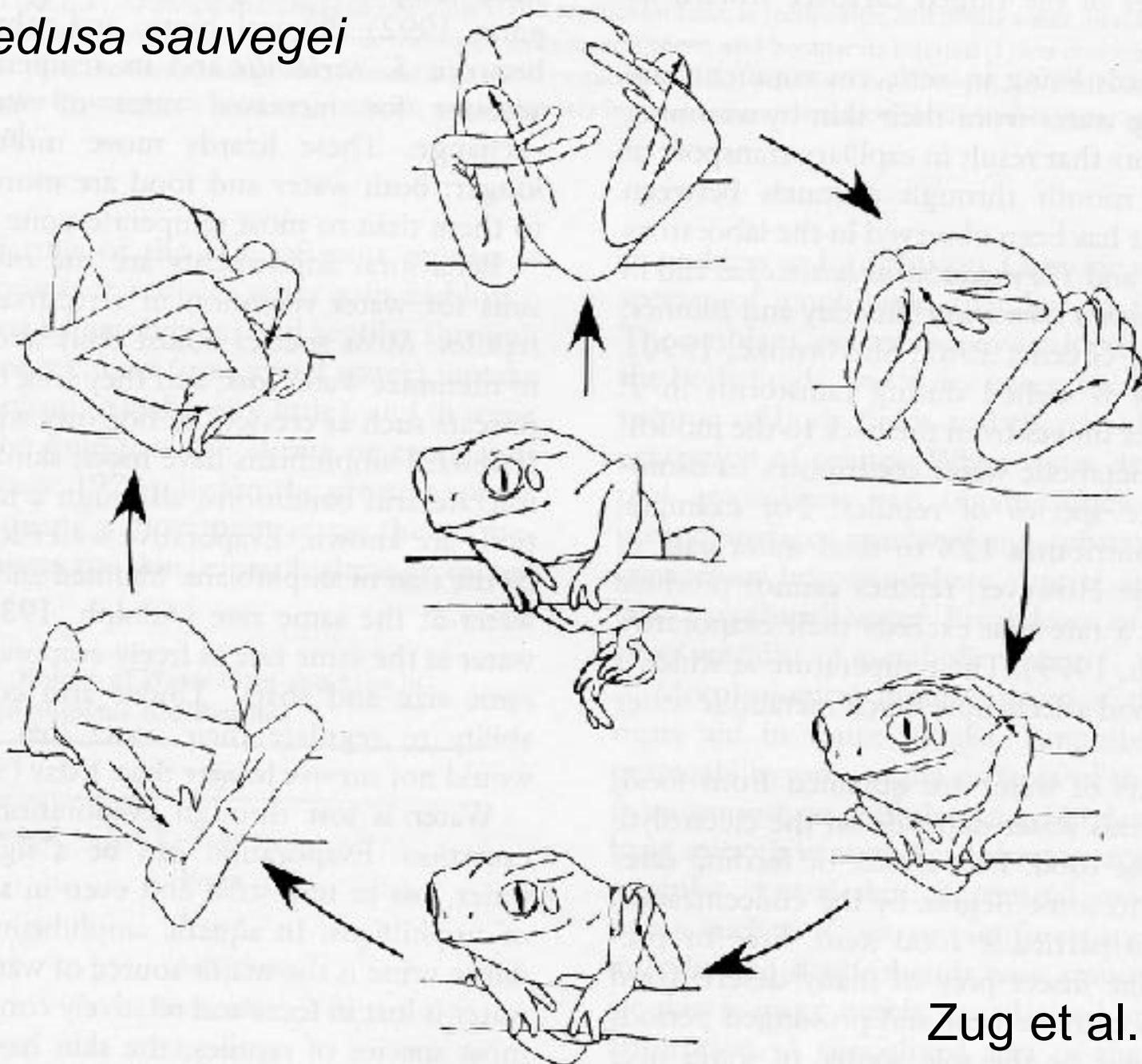
Evaporation

- Some amphibians can control water loss
- Example: dried mucus on skin, cocooning





Phyllomedusa sauvegei



Zug et al. 2001

Graham Thompson



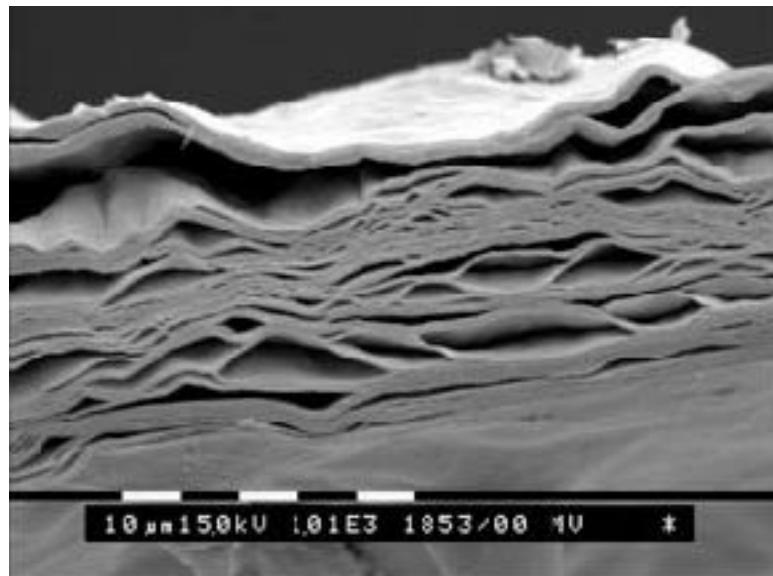
Northern burrowing frog *Neobatrachus aquilonius*

Graham Thompson



Northern burrowing frog *Neobatrachus aquilonius*

Graham Thompson



Northern burrowing frog *Neobatrachus aquilonius*

Losing water

evaporation

urine and
feces

salt
glands

Urine and Feces

- Water is lost in urine and feces
 - Key problem: getting rid of nitrogenous wastes
-

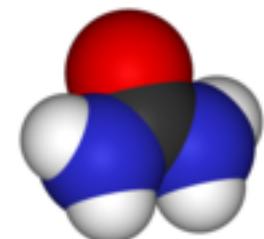
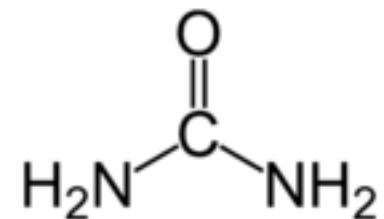


"Ammonia! Ammonia!"

Drawing by R. Grossman; © 1962,
The New Yorker Magazine, Inc.

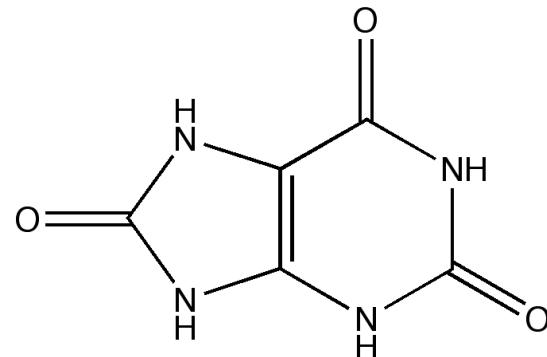
Urine and Feces

- Three main options
 - Ammonia
 - Soluble in water, but highly toxic
 - Used by aquatic species
 - Urea
 - Soluble in water, nontoxic
 - Used by terrestrial frogs



Urine and Feces

- Three main options
 - Uric acid
 - Insoluble in water
 - White paste
 - Conserves water, still gets rid of nitrogen
 - Bird poop



Losing water

evaporation

urine and
feces

salt
glands

Salt Glands

- Many reptiles have a specialized salt gland that can excrete salt (K^+ and Na^+ ions) in high concentrations
- Saves water



Homeostasis

- Water balance
- Heat balance
- Water and heat in the environment

Heat Transfer in Animals

Heat energy
gained



Heat Transfer in Animals

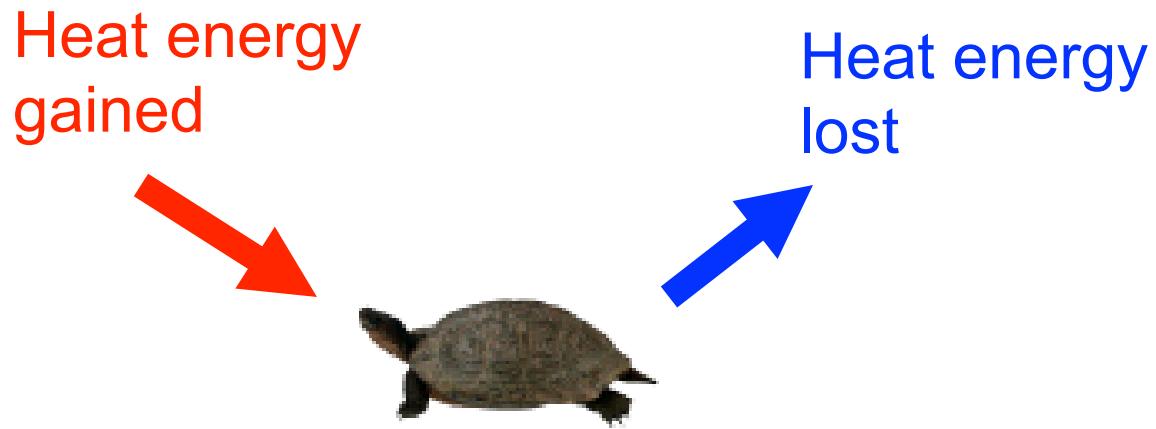
Heat energy
gained



Heat energy
lost



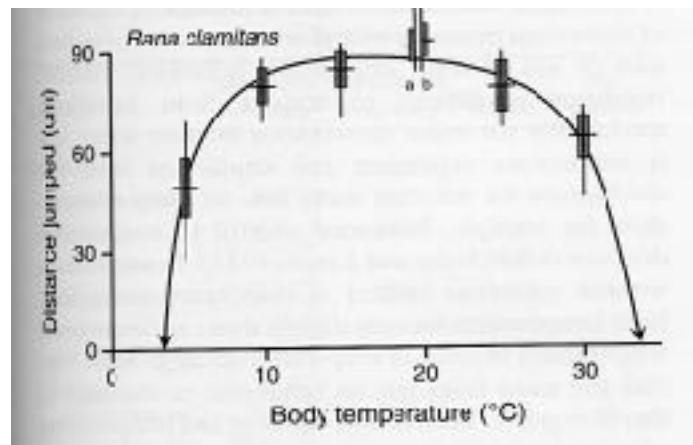
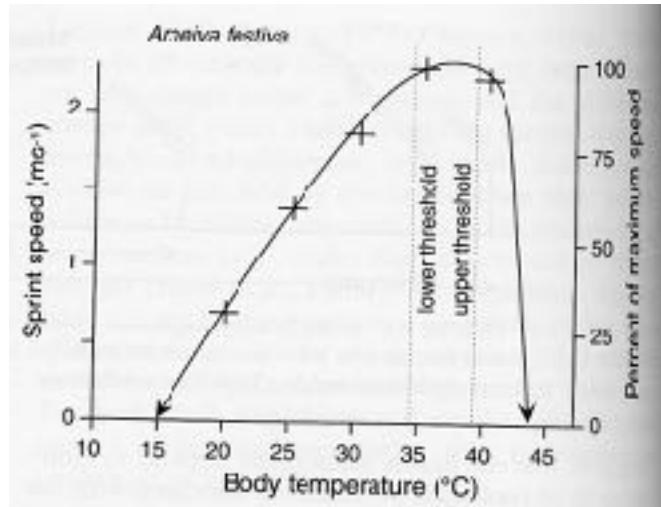
Heat Transfer in Animals



At thermal equilibrium:

Heat energy gained = Heat energy lost

Why does this matter?



Heat transfer in animals

solar
radiation

metabolic
heat

infrared

convection

condensation/
evaporation

conduction

Heat transfer in animals

solar
radiation

metabolic
heat

infrared

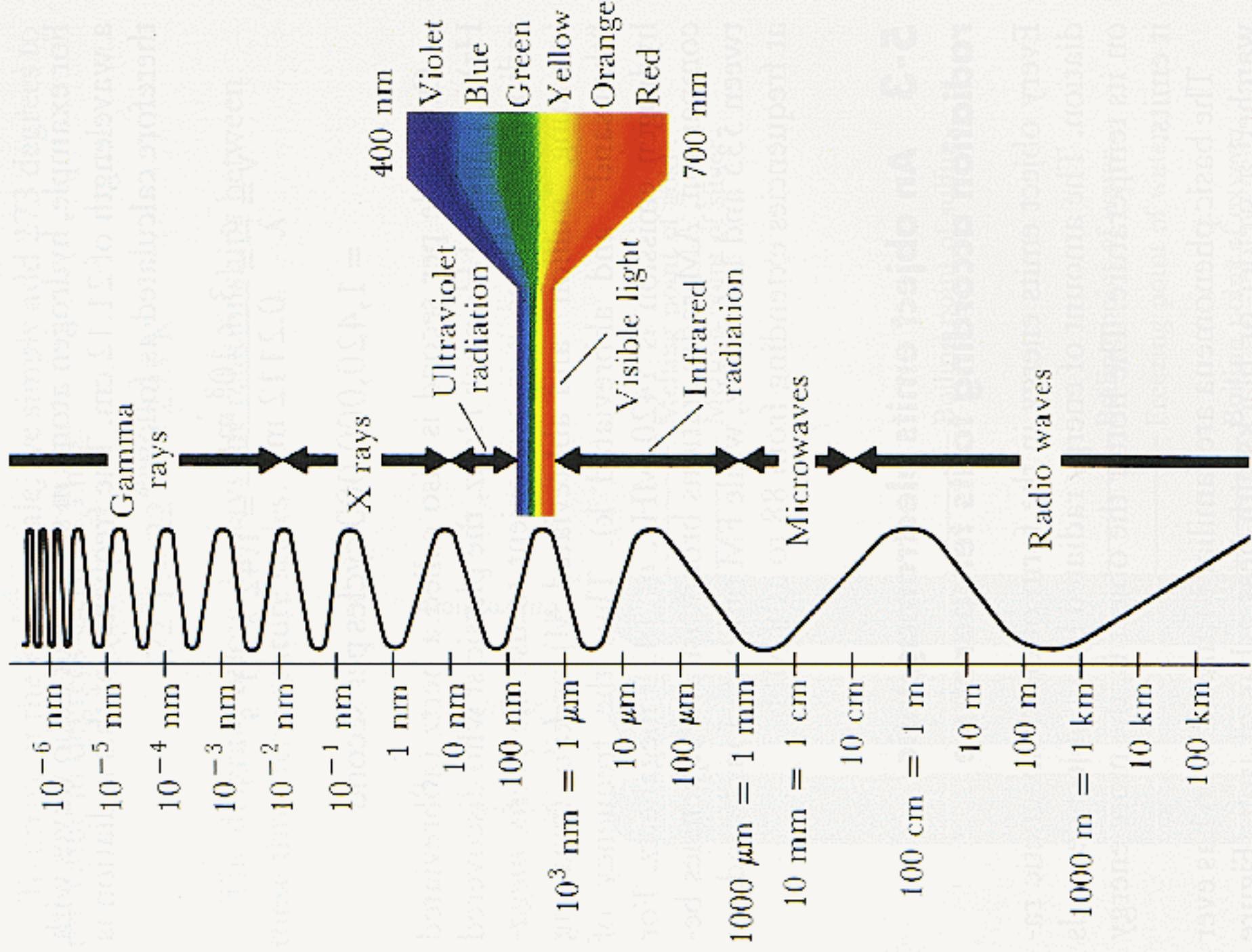
convection

condensation/
evaporation

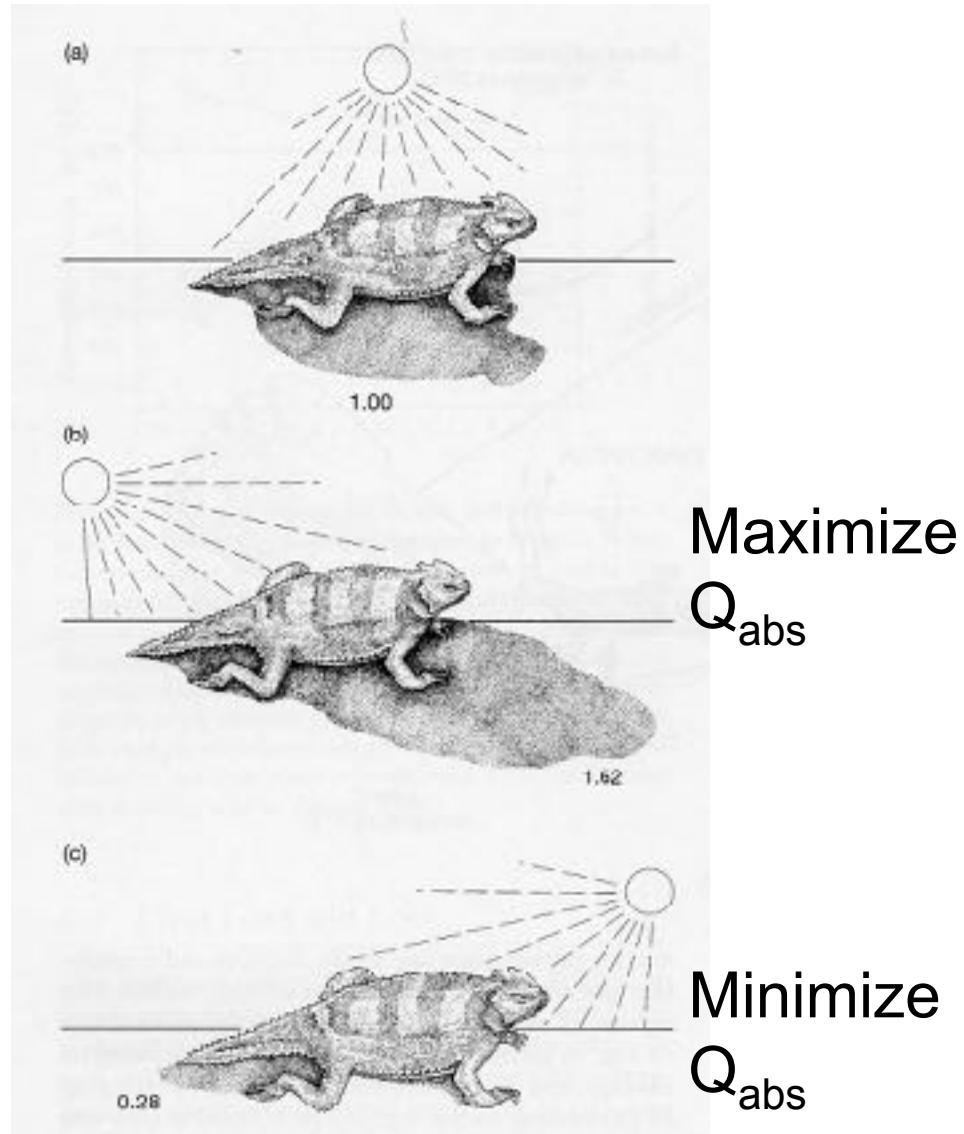
conduction

Heat Transfer in Animals

- 1. Solar radiation - absorbed by the surface of the animal
- 400 - 1500 nanometer wavelengths



Horned lizard
(*Phrynosoma cornutum*)
controlling the absorption
of solar radiation by
adjusting body posture



Heat transfer in animals

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conduction

Metabolic heat production

- Metabolic processes are chemical reactions
- In living things, these reactions tend to produce heat
- Endotherms rely on this heat to maintain constant body temperature
- Most herps do not - although they do still generate some metabolic heat

Metabolic heat production



pbs.org

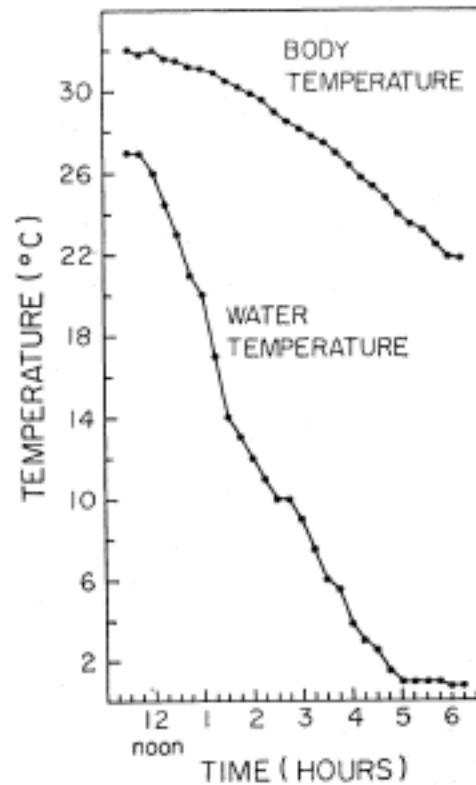


Fig. 1. Body and ambient temperatures for a leatherback turtle during cooling in water.





Heat transfer in animals

solar
radiation

metabolic
heat

infrared

convection

condensation/
evaporation

conduction

Infrared radiation

- All objects emit infrared (black body) radiation
- Depends on temperature difference, surface area, and emissivity of skin

Infrared radiation

Mojave fringe-toed lizard *Uma scoparia*



Photo © Randy Babb



Ventral - low emissivity
(shiny surface)

Dorsal - high emissivity
(matte surface)

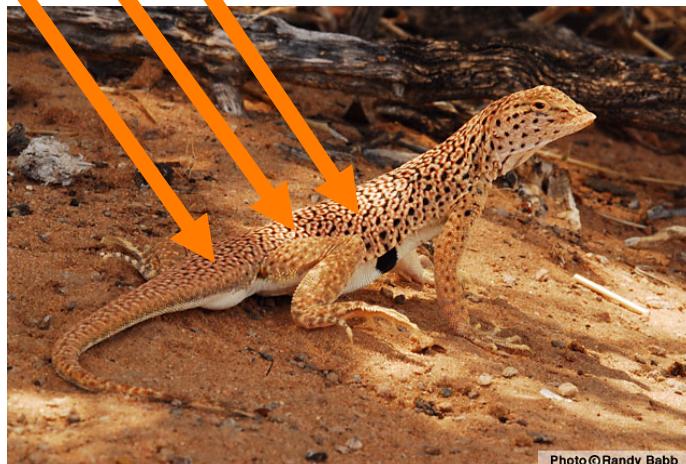
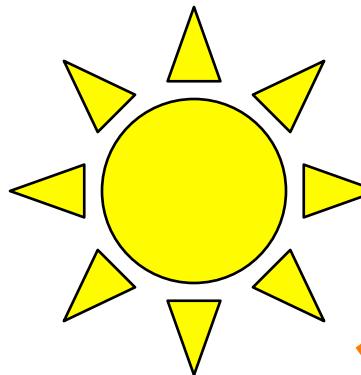


Photo © Randy Babb



Photo © Randy Babb



Heat transfer in animals

solar
radiation

metabolic
heat

infrared

convection

condensation/
evaporation

conduction

Convection

- Heat exchange between the animal and the fluid medium surrounding it
- Flowing air or water
- Depends on temperature difference, surface area, and convective coefficient

Convection

- Convective coefficient dominated by body size



Side-blotched lizard
Uta stansburiana



Chuckwalla
Sauromalus obesus

Convection

- Convective coefficient dominated by body size



Side-blotched lizard
Uta stansburiana



Chuckwalla
Sauromalus obesus

Morning - cold air temperature

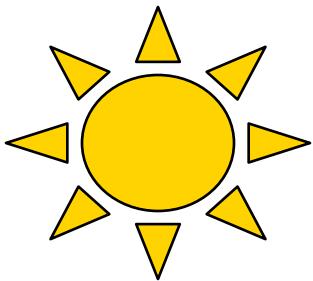


Photo © 2005 Tom Brennan

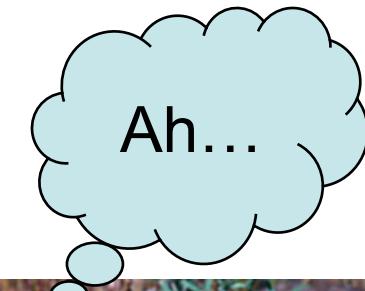


Photo © Randy Cobb

Afternoon - hot air temperature

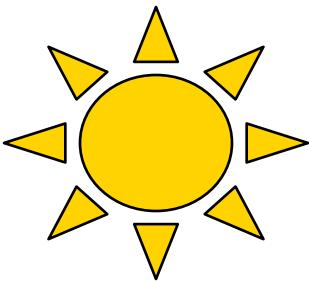
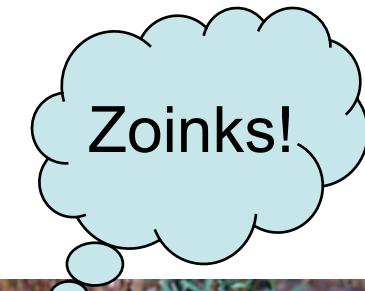


Photo © 2005 Tom Brennan



Zoinks!



Heat transfer in animals

solar
radiation

metabolic
heat

infrared

convection

condensation/
evaporation

conduction

Evaporation

- When water evaporates, it takes in heat
- Cools the surface
- Reptile skin basically impermeable to water - little evaporative cooling
- Some have adaptations - panting, gular fluttering
- Amphibian skin highly permeable
- Bullfrogs can spend an entire day in the hot sun cooling by evaporation

Heat transfer in animals

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radiation

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condensation/
evaporation

conduction

Conduction

- Transfer of heat to or from surfaces
- Primary source of heat for nocturnal species
- Can adjust posture to affect conduction



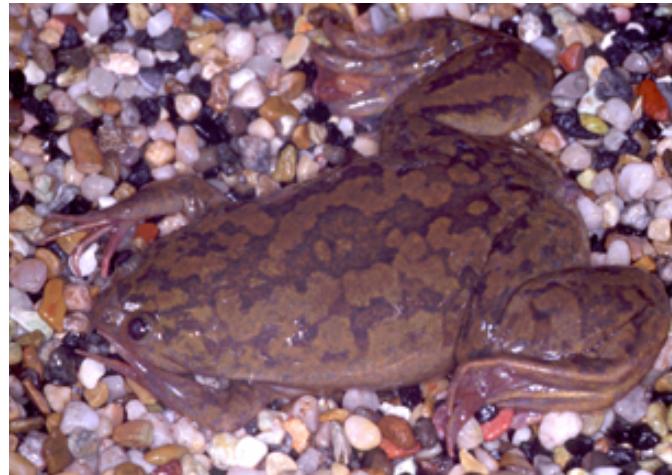
Shovel-snouted lizard (*Meroles anchietae*)



Side-Blotched Lizard (*Uta stansburiana*)

Conduction

- Major form of heat exchange in water
- Difficult for aquatic species to have temperatures that differ from surrounding water



Xenopus laevis - African Clawed Frog

Homeostasis

- Water balance
- Heat balance
- Water and heat in the environment





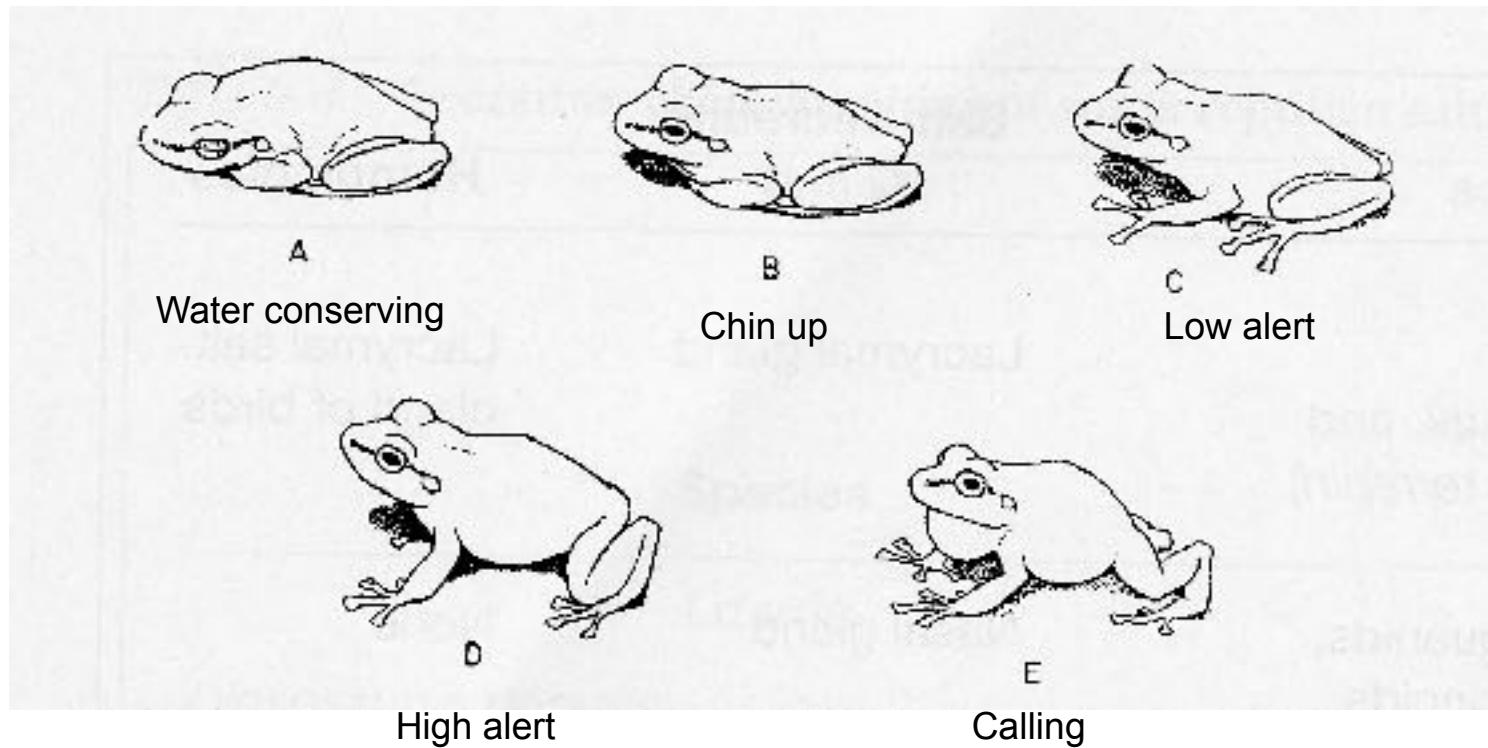
Managing water

- Herps have to manage water over both short and long time scales
- Use a variety of behavioral and physiological mechanisms

Short-term Water Balance

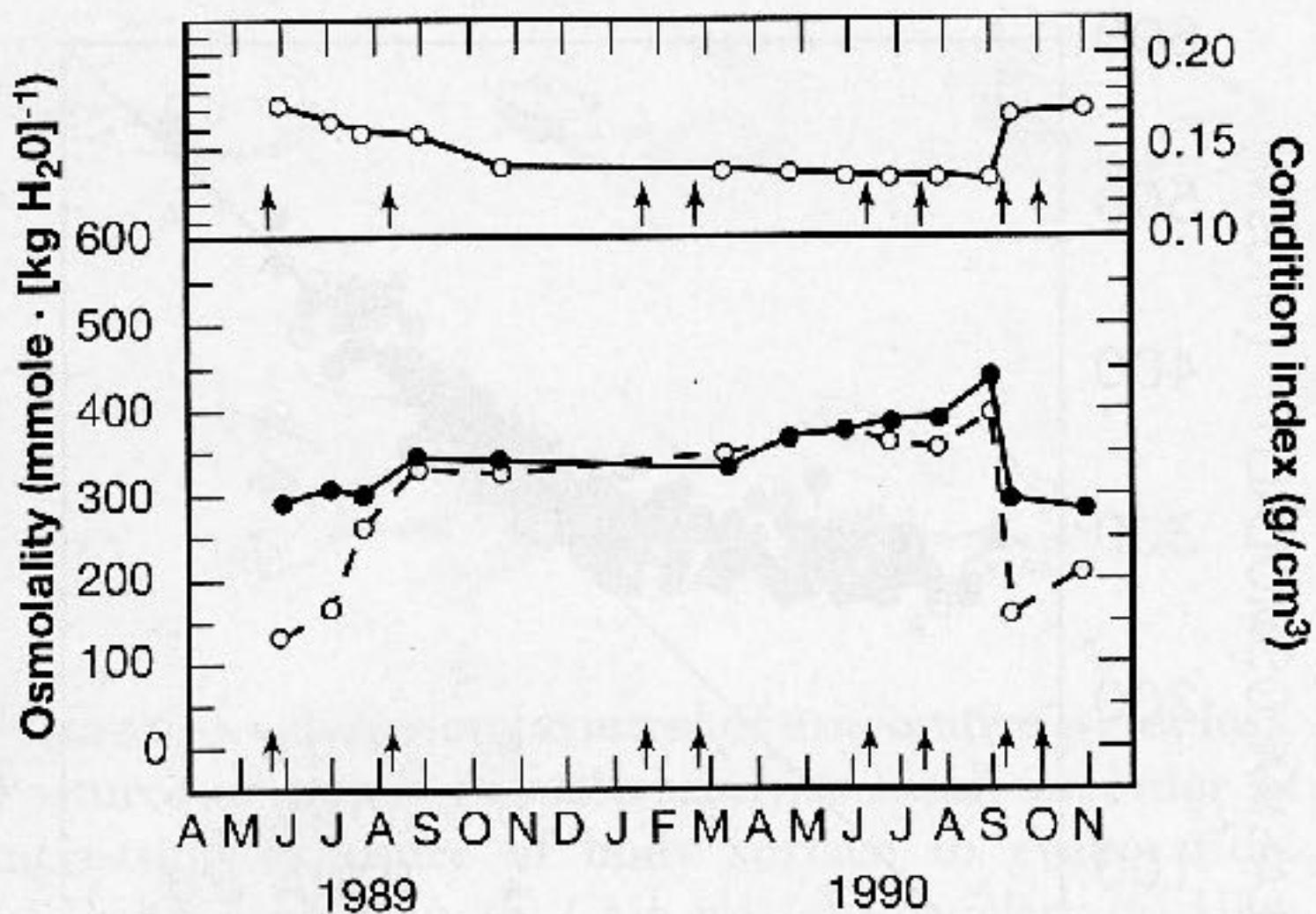
- Many herps have daily cycles related to water balance
- Especially common in terrestrial amphibians

Example: Posture of coquí



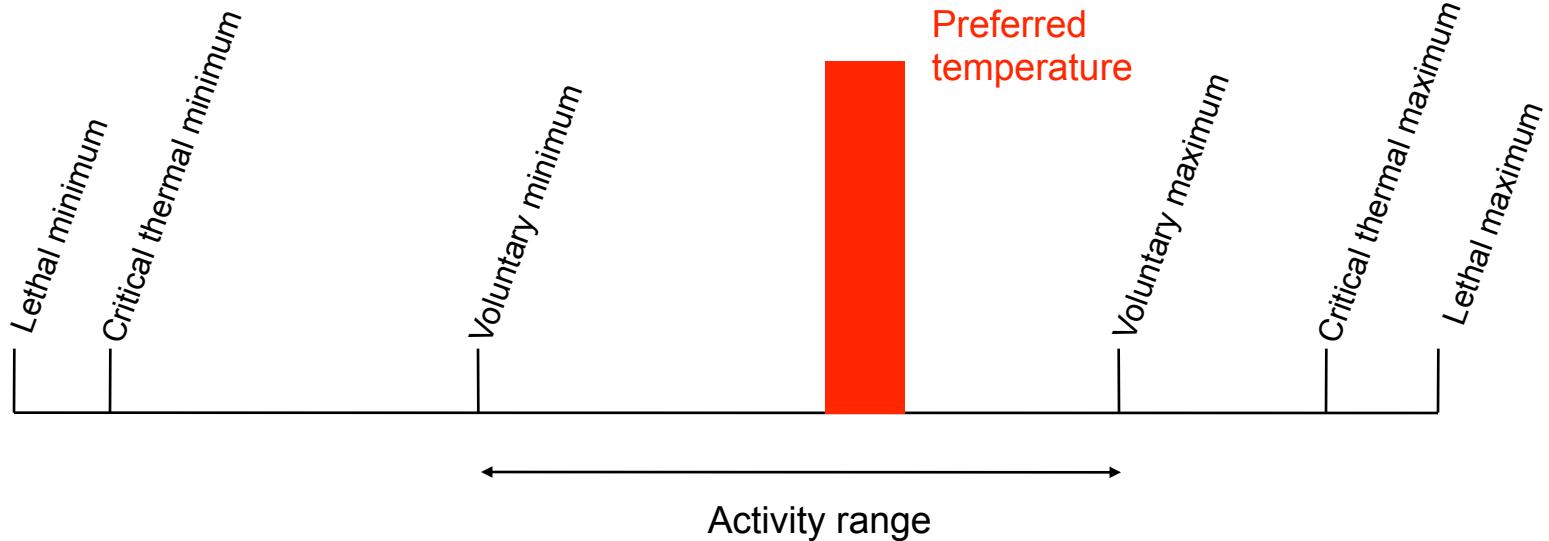
Long-term Water Balance

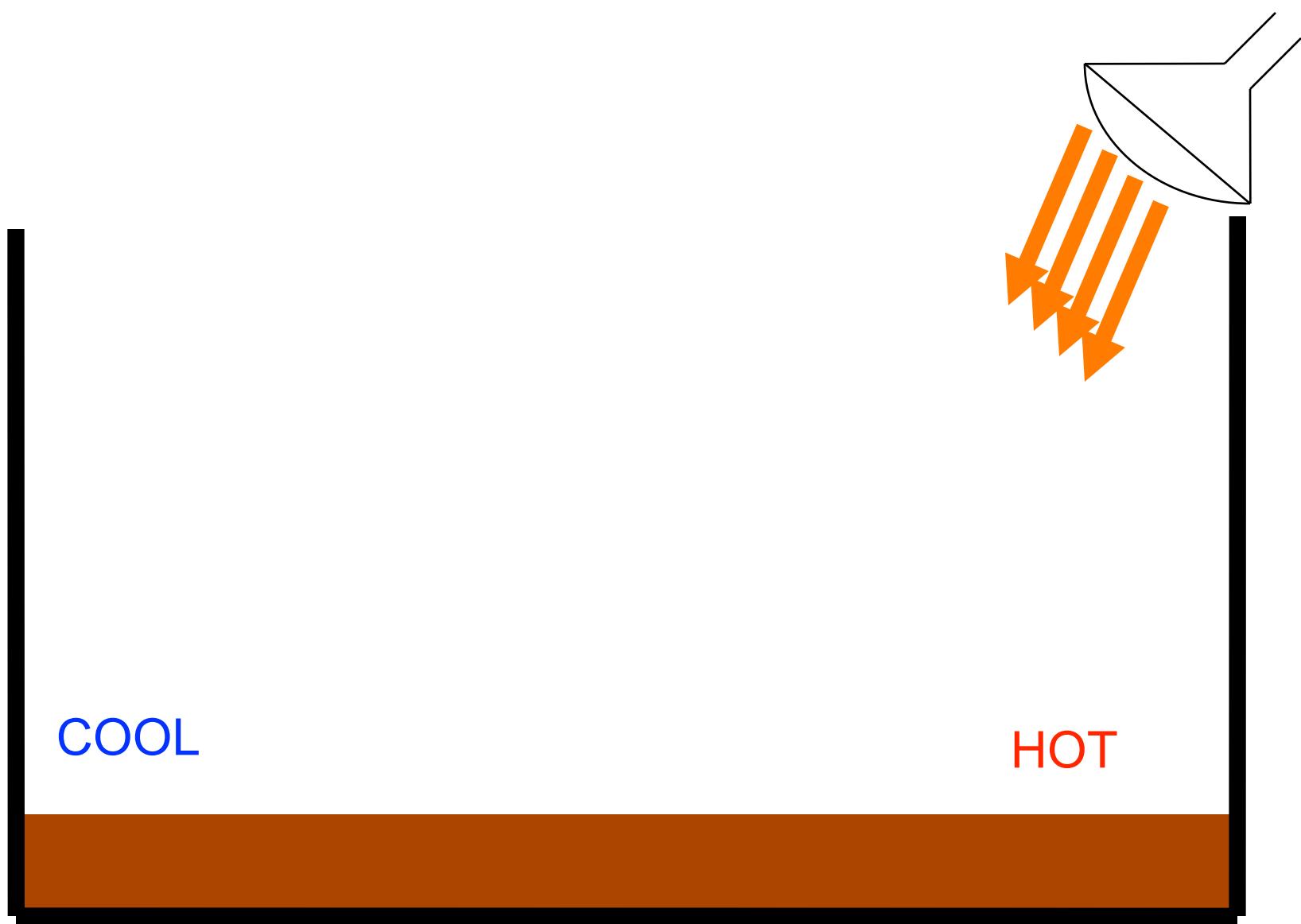
- Water flux is much slower in reptiles
- Water, salt can fluctuate over long time periods
- Example: desert tortoise



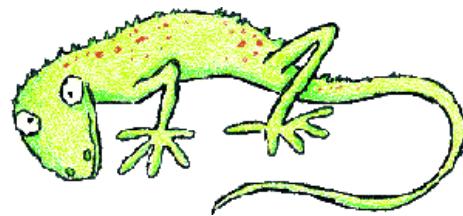
Behavioral Thermoregulation

- Ectotherms are not “cold blooded”
- Most species maintain their body temperatures within a narrow range

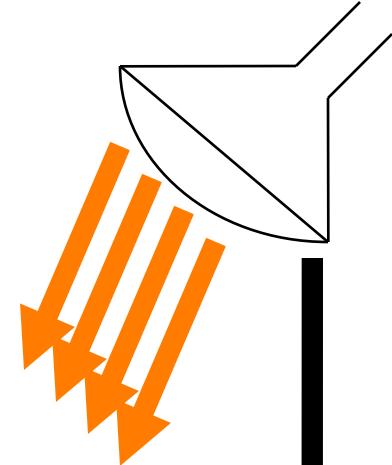


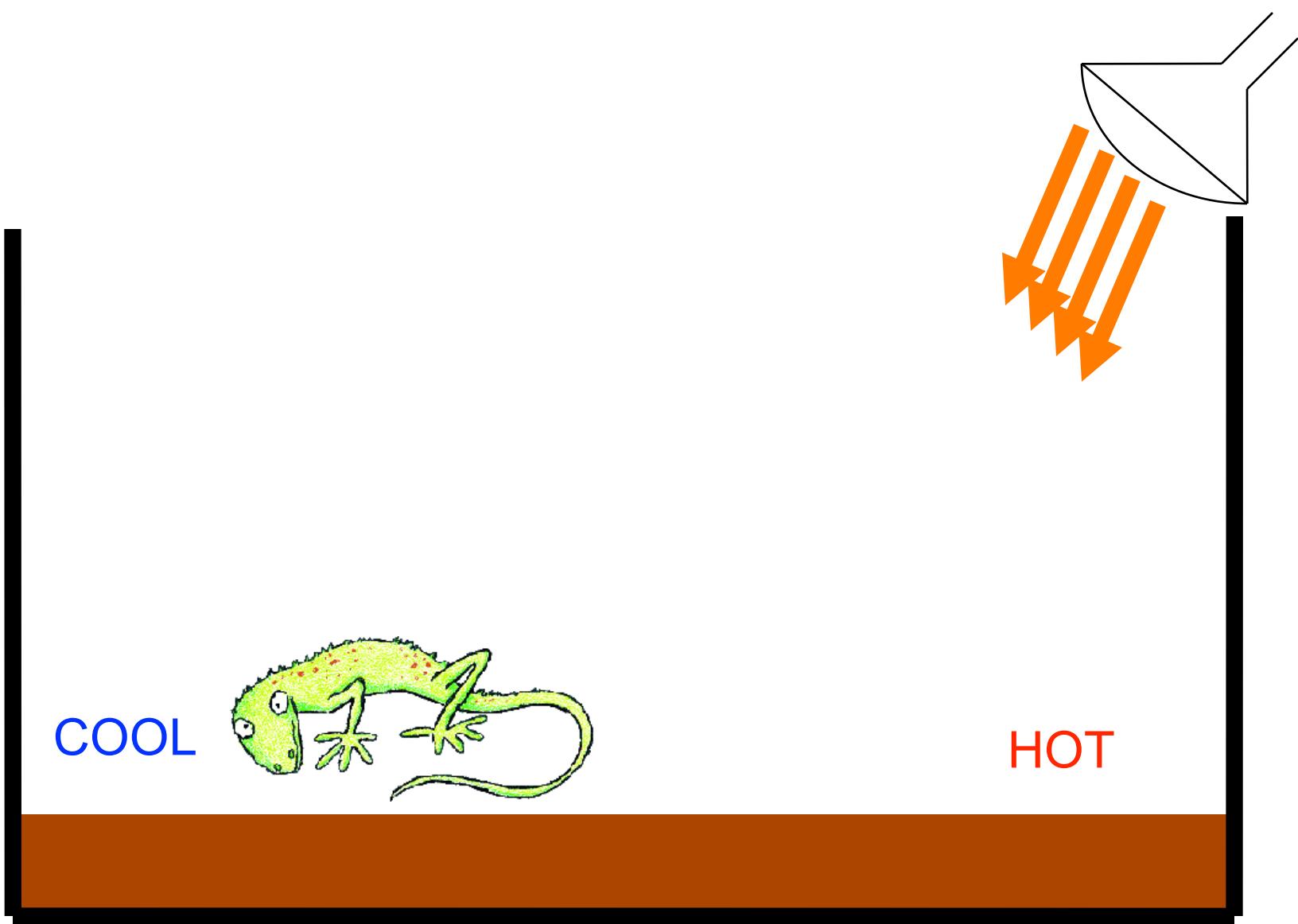


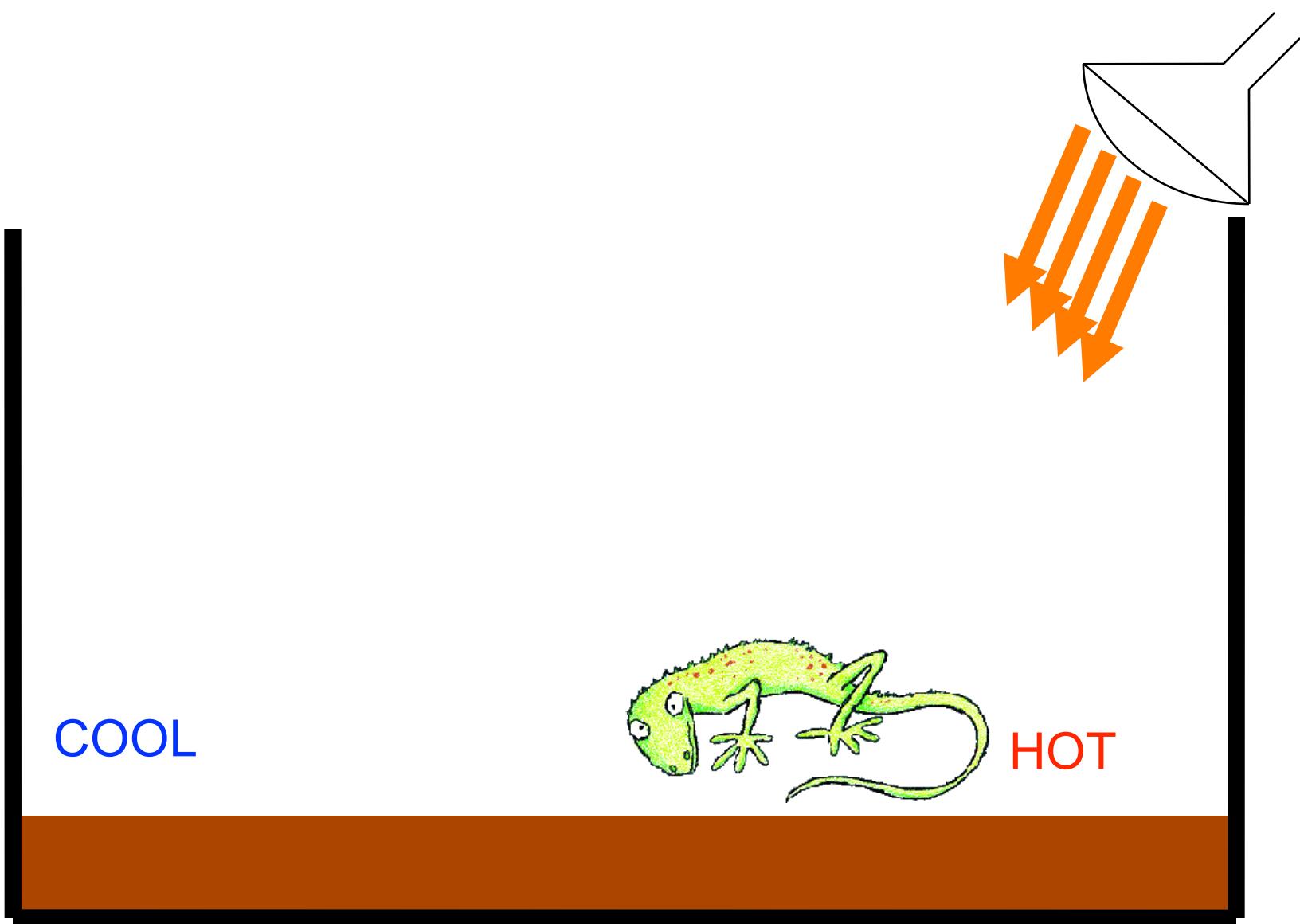
COOL

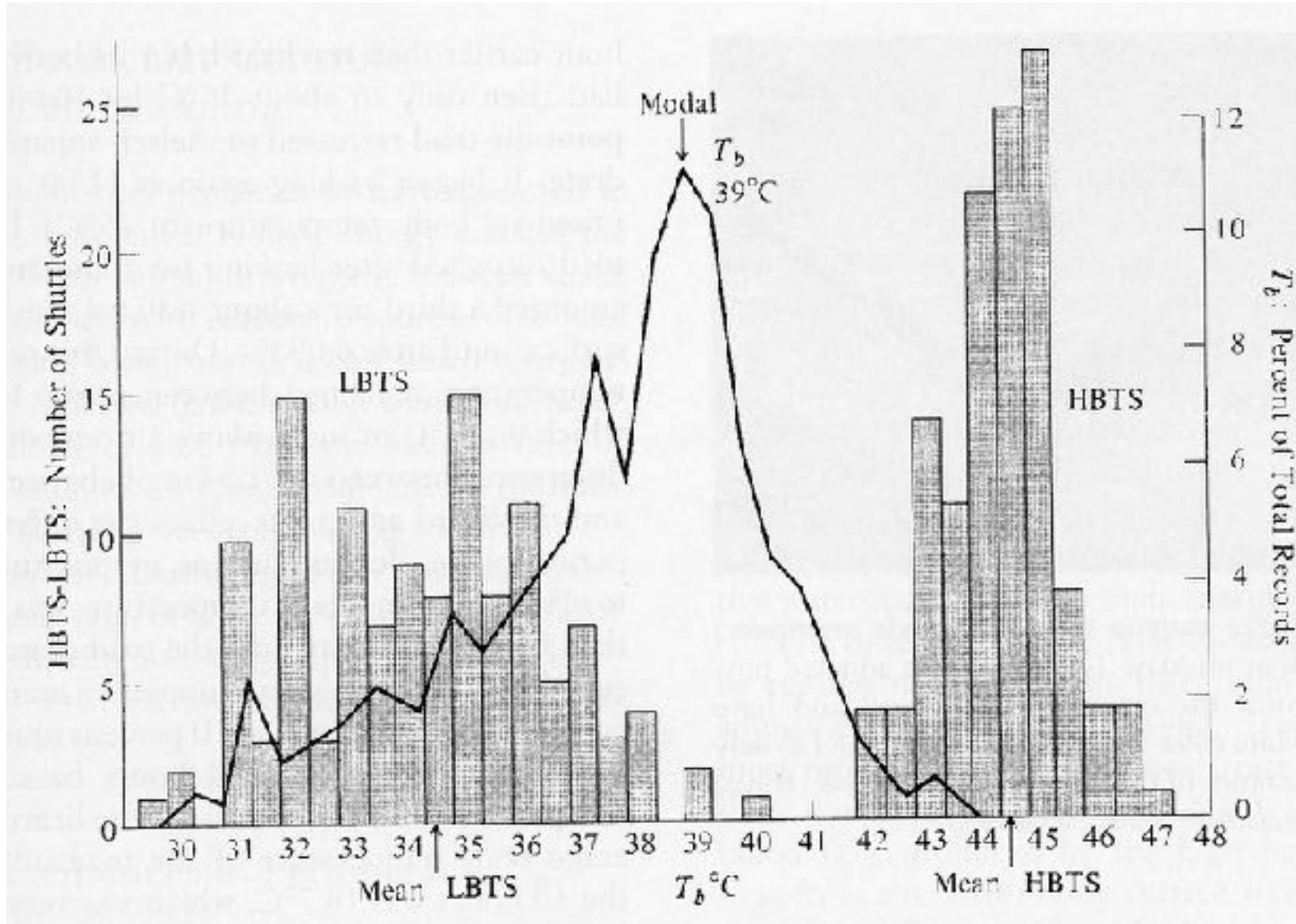


HOT









Desert iguana, *Dipsosaurus dorsalis*